The World Geodetic Network System and the Amendment of the Japanese Surveying Law

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Key words: Japanese Surveying Law, Local Geodetic System, World Geodetic System, Readjustment of Control Points and Conversion of Coordinates System.

ABSTRACT

The Japanese Diet has approved an amendment of the Japanese Surveying Law in June 2001. The most important amendment is an adoption of the new geodetic system such as the reference ellipsoid as well as geodetic datum.

This amendment was issued in accordance with the international flow; the unification of world geodetic system, the recommendation of IUGG, the wide spread of GPS system and so forth.

Japan had adopted the BESSEL ellipsoid and TOKYO datum so far, as the general standard for the use of the whole surveying. These elements are going to replace to the GRS 80 as well as to the ITRF 94 from April 1, 2002.

The Geographical Survey Institute, Ministry of Land, Infrastructure and Transport, has already prepared the transform system of control points coordinates from the old to the new one, and has printed the mention for both old and new longitudes and latitudes on the national maps.

This paper describes the present status of geodetic system for some countries in the world and problems to be hereafter solved for the adoption of world geodetic system.

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1. INTRODUCTION OF THE JAPANESE SURVEYING LAW

In the Japanese Surveying Law (issued in 1949), Survey Standards (elements of reference ellipsoid and geodetic datum etc.), Procedure of Basic Surveys (Fundamental Surveys carried out by the Geographical Survey Institute), Procedure of Public Surveys (Surveys carried out by local public bodies etc.), Qualification of Surveyors, Registration of Survey Companies are regulated.

In Japan, the modern fundamental control surveying all over the national land started at the middle of 19 century. At that time, the Japanese government adopted Bessel ellipsoid 1841 as the reference ellipsoid and determined the values of geodetic datum (Tokyo datum) by means of astro-geodetic surveying. The coordinates of control points were measured by means of triangulation method. Since then, control points have been repeatedly measured because crustal movements according with earthquakes and volcanic eruptions are very large in Japan. For recent several decades, repetition surveys have been carried out at 5-year intervals. Trilateral surveying has been adopted during the period from 1960 to 1980' in accordance with the development of electro-optical distance measuring instruments (EDM). GPS (Global Positioning System) surveys have been adopted for these 10 to 20 years, though the coordinates values have been transformed from WGS (World Geodetic System) 72 or WGS 84 to the conventional Japanese geodetic system.

2. OUTLINE OF THE AMENDMENT OF THE JAPANESE SURVEYING LAW

The outline of the amendment of the geodetic standards is as follows:

(1) Alternation of geodetic system from local geodetic system to so called the world geodetic system of which the center of ellipsoid lies on the center of the earth's mass.
(2) Adoption of GRS (Geodetic Reference System) 80 as reference ellipsoid from Bessel ellipsoid 1841.
(3) Adoption of ITRF (International Terrestrial Reference Frame) 94 as geodetic coordinates system from Tokyo datum.
(4) Distance and area are calculated on the ellipsoid, whereas old those were calculated on the horizontal plane.

3. REASON WHY WE AMENDED THE GEODETIC REFERENCE SYSTEM

Geographical Survey Institute (GSI) manages national geodetic control points. The GSI has repeatedly been observing national control points, and has obtained different coordinates values for each control point. The reasons of the results are caused mainly by the following two factors.

One is due to the crustal motion in accordance with earthquakes and volcanic activities, and the other is due to the development of surveying techniques.

The triangulation with theodolites had been employed during the period from 1860 to 1960, the trilateration with EDM had been employed during 1960 to 1980, and GPS and VLBI (Very Long Baseline Interferometry) surveys are employed at present.

In addition to the development of surveying instruments, the development of computers cannot be negligible. In early days, the capacities of computers were poor, so that the simultaneous solution of the control points all over the national land was impossible. Therefore calculation gaps existed between the clusters of area. At present, simultaneous calculation of all control points in the national land is possible, and then we can obtain the homogeneous solution.

Before considering the alternation of local geodetic reference system to the world geodetic reference system, the GSI had to readjust the coordinates of the control points through out the Japanese Islands. However the alternations of the coordinates values of the control points are socially not so easy though it is technically possible. Because various surveys and various preparations of maps have been already carried out in accordance with the old results of the control points.

Therefore the GSI has decided after due consideration that the readjustment of control points and the introduction of the world geodetic system should be executed at the same time. The introduction of the world geodetic system cannot be relatively denied by the society, because IUGG (International Union of Geodesy and Geophysics) recommends the world geodetic system. It is desirable that every country uses the uniform geodetic system. Propulsion of internationalization is not denied by anyone in Japan.

The GSI emphasized the internationalization of geodetic works to gain the approval of the amendment of the surveying law.

4. TECHNICAL BACKGROUND, INFLUENCE AND ITS COUNTERMEASURE IN AN ALTERNATION OF THE GEODETIC REFERENCE SYSTEM

In Japan, we have established a GPS observation network composed of about 1,000 permanent stations all over the national land. 24-hour continuous GPS observation is implemented at each station. In the center of the observations, located in the GSI at Tsukuba

Science City, various analyses such as baseline analysis, simultaneous adjustment of coordinates and crustal motion analysis are carried out. Such GPS observation network cannot be seen in any other countries besides Japan. The average span distance of permanent stations is about 25 km.

There are 4 VLBI observation stations covering the national land, and international observations have been conducted there.

Moreover the GSI has conducted the geoid observation at 20 km span along about 20,000 km of leveling route. The precise form of geoid in Japan has been clarified.

By the combination of observations mentioned above, the technical conditions have been fulfilled for the alternation the local geodetic system to the world geodetic reference system. The GSI readjusted the coordinates of the first order, second order and third order triangulation points (composed of about 40,000 points), and prepared the conversion software for every control point between the old coordinates and new ones. The differences between new and old coordinates of control points exceed 400 to 500 m in distance.

The influence due to the alternation of geodetic reference system is not so small. Local administrative bodies such as prefectures, cities, towns and villages have to recalculate or resurvey their own control points. The ones who prepare terrestrial maps take into account the difference of the longitude-latitude values of the neat lines between old and new maps. The cadastral maps have also to be readjusted.

Both the GSI and the Japanese Association of Surveyors were gave lecture classes for the persons in charge of surveying in the local administrative bodies and private surveying companies, at many places in Japan. The GSI opened a website for conversion system between old and new coordinates, and put both old and new indications of longitude-latitude on the sheets of national terrestrial maps.

5. THE GEODETIC REFERENCE SYSTEM IN THE WORLD

The author investigated an actual status of geodetic reference system in the world especially lying a target on developed countries. There are not many countries that regulate geodetic reference system in the law or in the act. Japan is a unique country in this point of view.

In the world, there are many countries that adopt the local system for practical surveying and adopt the world system for scientific purposes.

The situation is presented in the following table.

6. PRACTICAL GEODETIC SYSTEM IN THE WORLD (As of Spring 2000)

Country	Reference Ellipsoid	Remarks
Japan	**Bessel** to **GRS 80**	**ITRF 94** from April 2002
U.S.A.	**GRS 80**	**NAD 83**
Great Britain	**Airy (1830)**	**ETRS 89** for ocean and science
Germany	**Bessel (1841)**	**WGS 84** for ocean
France	**Clarke (1880)**	**European 1950** for ocean
Canada	**GRS 80**	**NAD 83**
Spain	**Hayford (1909)**	**NGO 1948** to **ETRS 89** for ocean
Norway	**GRS 80**	**NGO 1948** to **ETRS 89** for ocean
Australia	**WGS 84** to **GRS**	**ITRF** from 2000

7. CONCLUSION

The introduction of the new geodetic reference system is, in general, very difficult because maps and other related miscellaneous matters are managed under the old geodetic system. This requires great expense, and the enlightenment on an idea for the conversion of coordinates of land is not so easy.

There may be the idea so that, it is enough if only the conversion values from the local system to the world system has been determined. I have no opposite opinion to that idea. But I also approve the idea, so that the standards should be homogeneously determined in the world according to the latest scientific facts, if it is possible.

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REFERENCE

The GSI Journal (July 5, 2001)